14. It's Not About Programming, It's About a Way of Learning: Evolution of Teacher Perspectives on Computer Programming Education

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Abstract: Integrating computer programming into the standard school curriculum has become an emerging trend around the world. In addition to the difficulties of implementing a new learning approach, teacher professional development for programming education often leaves out the potential of programming as a tool for creative learning. To address this issue, the researchers developed a teacher professional-development program targeting elementary and middle school teachers, focusing on the role of programming to support creative learning in schools. This 4-month-long, blended (i.e., in-person and online) program focused particularly on providing teachers with means to engage in creative programming themselves, reflect on the process, design and try out a lesson idea, and iterate on the lesson idea. This paper reports on the shifts in the teachers' understanding of programming education and challenges that emerged through this professional-development experience. The most compelling shift we observed was how teachers started to see programming education as an opportunity to teach their students how to learn. The paper also shares a few lessons learned from this study as recommendations for practitioners.

Background

Integrating computer programming into the standard school curriculum has become an emerging trend around the world. This trend provides a unique and challenging contexts for teacher learning (Menekse, 2015); for example, most teachers have to teach computer science or computer programming without any prior background or training; programming education often requires cross-curricular instruction, which most teachers are not used to; and there is simply a lack of teachers who have taught programming in a classroom, creating few opportunities to learn from other teachers. In addition, early adopters state that the goals of programming education are not limited to skills in writing programs but also include abilities to design and build solutions to problems (Grover & Pea, 2013; Papert, 1980; Wing, 2006). Thus, teachers are required to not only deliver knowledge and skills about computer programming but also to facilitate students' development of their own knowledge through engaging in exploratory, creative learning processes (Resnick, 2017). These emerging needs of programming education triggered numerous new initiatives providing resources and professional-development opportunities targeting schoolteachers. However, too often those programs focus exclusively on how to write computer programs, rather than helping teachers gain an understanding about *why* students need to learn to program and *how* to facilitate their learning process using programming.

To address this issue, we created a professional-development program that provides teachers an opportunity to build their own understanding of how programming might help their teaching through engaging in the creative process that involves trying out, reflecting on, and iterating their teaching within their own contexts. This paper provides an overview of this professional-development program, held in 2018 at a rural prefecture (a political subdivision) in Japan, and reports on the experiences of several teachers who participated in this program, highlighting how this approach to professional development impacted the ways teachers view programming education and its pedagogy. The program was also held in 2019 and 2020, each time adding several revisions to the program design. The insights from those newer

iterations have been shared in other publications (e.g., Murai & Muramatsu, 2020). Finally, we discuss lessons learned about teacher professional development for creative programming and offer recommendations for applying them.

Creative Programming for Teacher Professional Development

Our professional-development program was built on an existing open online course (lcl.media.mit.edu). The course was focused on creative learning, a pedagogical method based on constructionism, a philosophy emerging from studies of children engaged in creative processes using programming (Harel & Papert, 1991). The original course was fully online; participants did not interact with one another in person. Taking the core ideas from the course, our professional-development program was designed as a blended course specifically modified to meet the needs of the teachers in the area. It was conducted in the local language (Japanese), and participants interacted with one another both in person and online.

Overview

This professional-development program was designed to be four months long, starting with a two-day in-person kick-off camp followed by three months of individual preparation. During this preparation time, teachers implemented the activity idea they developed at their own school while engaging in biweekly online check-in calls with other participating teachers (see Figure 1). Each teacher tried out his or her lesson ideas by the end of the third month and shared the reflections and ideas for iteration at a final presentation in person.

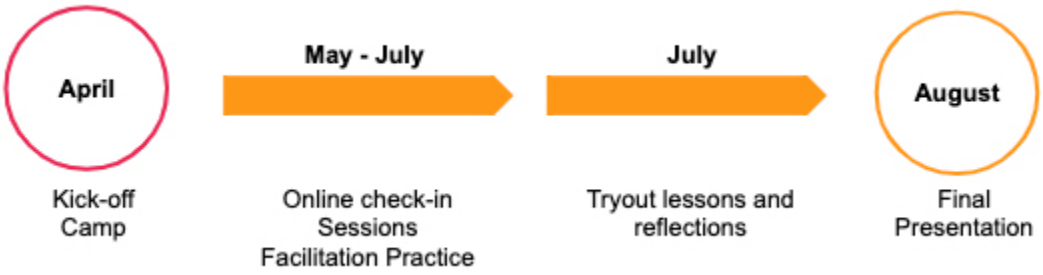

Figure 1. Schedule of the program.

Kick-Off Camp

The two-day intensive kick-off camp consisted of four major types of activities: making, reflections, design, and discussions based on a presentation. Figure 2 shows the timetable of the program.

Day 1

9:00	Opening
9:15	Icebreaking
9:30	Introduction to Creative Programming
10:00	Making Activity 1 + Reflection
12:15	Lunch
13:00	Making Activity 2 + Reflection
15:15	Conversation about the New Curriculum Standard
15:30	Making Activity 3 + Reflection
16:30	End-of-day Reflection
18:00	Reception

Day 2

8:30	Breakfast
9:00	Warm-up
10:00	Design Activity
12:15	Lunch
14:00	Share out
15:00	End-of-day Reflection
15:15	Closing

Figure 2. Timetable of the kick-off camp in 2018.

Making. The making activities were designed to provide teachers with firsthand experience of creative programming. Instead of step-by-step instructions for how to create a particular project, these making activities provided open-ended themes (for example, "make something that makes the classroom funny") to encourage teachers to engage in tinkering, one of the core components of creative learning (Resnick, 2017). These activities were also used as opportunities to introduce different technologies to teachers, such as an educational electronic circuit board micro:bit (microbit.org). During and after the making activities, several minutes were allocated for teachers to showcase their activities and exchange feedback with one another.

Reflections. Teachers were asked to reflect on their experience after almost every activity during the camp. Reflection is an important process to turn an experience into knowledge and skills that one can use in practice (Schön, 1992). Teachers were asked to look back on their own experience making or designing projects to gain a firsthand understanding of how it feels, what is helpful, and what might be challenging for their students. We prepared several reflective activities encouraging teachers to visualize their actions, thoughts, and emotions and help them adopt an objective perspective about their experiences.

Design. Design activities were another important component of the kick-off camp. In groups of three, teachers were asked to design a creative-learning lesson they could implement in their classrooms or after school. Following a workshop protocol called the Imagine-Create-Share framework, teachers brainstormed and prototyped how they would support students to come up with ideas (Imagine), how they could tinker with materials and create objects they envisioned (Create), and how they could share with others and gain constructive feedback (Share). Teachers prototyped the ideas by creating either slide shows or sketches. At each design activity time, teachers shared their ideas with members of their group as well as with the whole group, receiving feedback at multiple points during the camp.

Discussions based on a presentation. Although this professional-development program emphasizes the importance of hands-on making and designing, the program organizers offered a few lecture-style presentations to introduce the historical background of computer programming education and creative learning, and a basic understanding of the field. For example, a 15-minute presentation on the creative learning framework (Resnick, 2017) and a 15-minute presentation overviewing the new curriculum standard were given at separate times during the kick-off camp. These presentations were designed to be short and to invite conversation so they would not be a passive experience for participants.

Online Check-in Sessions

Since one of the goals of this professional-development program was to cultivate a community of teachers in the local region, it was important to provide an environment where participating teachers could continue the conversation and stay connected with one another. After the kick-off camp, online check-in sessions held once every two weeks aimed to support teachers in sharing what they were working on, asking for help when needed, and giving feedback to one another. Each check-in consisted of 30–45 minutes of discussions based on a case or a talk, followed by up to one hour of sharing in which each teacher participated. Teachers were encouraged to comment on or share ideas with one another about what they had been working on.

Tryout Lessons

Teachers were asked to brush up their lesson idea through online check-in sessions and then to select an opportunity to try out the idea with children. Several teachers selected their own classrooms, whereas other teachers selected afterschool environments such as club activities or weekend workshops. After the tryout sessions, teachers were asked to debrief and reflect on the experience, including what went well, what did not go well, and how they would do it differently.

Final Presentation

Teachers were asked to put together a poster to share the lesson they eventually conducted (many teachers went through multiple changes during the check-in weeks), how students reacted, lessons learned, and recommendations to other teachers. All teachers stood next to their posters, gave a short introduction, and then explained the posters to their audience. Teachers were also asked to reflect on their professional development in small groups.

Methods

In this section, we discuss the findings from the study of teachers who participated in a professional-development program in 2018 targeting public elementary and middle school teachers in rural Japan. In Japan, the Ministry of Education has announced new curriculum standard guidelines to be implemented starting in 2020, listing programming as a compulsory item for every public elementary school curriculum (Shoto-Chuto-Kyouikukyoku-Kyouikuka, 2016). Our professional-development program was prompted by the prefectural government's need to prepare teachers for the policy change. A case study method was chosen in order to gain deeper insights into teachers' experiences as a contemporary phenomenon in real-world contexts (Yin, 2017). In collaboration with several other learning designers and organizers, the two researchers for this study also played primary roles as designers and organizers of this professional-development program, reflecting on their own views, their understanding about the program, and the experiences of teachers in this program.

Participants

A total of 14 teachers with varying teaching and programming experiences from across the prefecture participated in the program. All participants applied based on their interests, yet some of them applied because of a strong recommendation by their school administration and the prefectural board of education in order to balance out regional representation in the program.

Data and Analysis

A primary source of data consisted of online pre- and postsurveys conducted with all participants before and after the program. The presurvey asked teachers about their expectations for the program and requested background information such as teaching history, while the postsurvey focused on their takeaways and feedback about the program. In addition, as part of the reflection process at multiple points during the kick-off camp, participants were asked to write down their expectations, concerns, and questions regarding computer programming education, using sticky notes. These sticky notes were collected and analyzed as data. The meeting minutes from a debrief meeting after the kick-off camp as well as records of the regular check-in sessions were also collected and examined in order to understand the experiences of participating teachers. Thematic analysis was conducted to identify emerging themes in participants' feedback. From the analysis, we examined and synthesized the lessons learned from this work that can be applied to other professional-development programs.

Results and Discussion

Overall, 13 out of 14 teachers participated in the final presentation, sharing their tryout sessions and lessons learned from their experience. This completion rate was a positive result but not surprising given that it is culturally uncommon for teachers to drop out of professional development supported by formal institutions such as the board of education and universities. The format and length of the tryout sessions varied depending on the contexts of each teacher, including the age of his or her students, the size of his or her school, and the curricular freedom or restrictions in his or her school. For example, a few teachers conducted a one-off class lesson, while other teachers conducted afterschool workshops. All of them used one programming language as part of their tryout session.

One of the significant shifts we identified in teachers' way of talking about computer programming education was their change in focus: from *what* their students need to learn to *how* their students need to learn. For example, one teacher who was asked to participate in the program to represent his district initially expressed doubt about why he had to teach programming to students, arguing that there must be more important things they needed to learn than programming. As he engaged in the activities and a series of reflections, he realized his positive emotional reaction from the creative process might be something his students would need in everyday school life. Another teacher, previously involved in much professional development on computer programming, described before participating in this program how she was not convinced about the common notion of programming as another form of knowledge she had to teach her students. As she took part in our program, she described how approaching programming as a creative learning process started to make sense, and she came to think that "programming may create an opportunity to bring a fundamental change to how we teach at school." Through reflecting on their own experience, both teachers started to see programming as an opportunity to teach their students how to learn through engaging in creative learning.

Other teachers mentioned that their confidence and comfort about teaching computer programming had shifted. For

example, one teacher who at first emphasized the importance of every student's having access to a laptop wrote, at the end of the program, that he realized technological kits were not necessarily a requirement to provide a good programming education. He had learned that there were other resources and ideas he could borrow from colleagues in the community. When he conducted his trial session with students during the club activity, he used an educational electronic circuit kit rented from a partner university while also implementing unplugged programming (i.e., a programming activity that does not use computers) for his own classroom with younger students, an idea presented by a graduate student. His case highlights that when teachers try out creative programming in their own environments and have a number of opportunities to work with their peers, they collectively gain more confidence and comfort to conduct programming in any environment.

Another change we observed was that several teachers shifted their attitude toward programming. When we asked teachers to write down their concerns and expectations toward programming education at the beginning of our professional-development program, many teachers expressed concerns and anxiety. In particular, several teachers described their concern about not being able to teach programming in "the right way." One of those teachers, however, mentioned that he started to realize that it is important to "try first" even when he was not sure how the trial might end up. Having the opportunity to ask questions during the online check-in meetings and reflect on things they could do helped him feel comfortable trying out an idea without complete preparation.

Some teachers also described that they started to notice challenges they did not see before about conducting creative programming. One example was the difficulty of getting support within the school. One teacher who had been actively implementing his own creative programming ideas described how difficult it was to get feedback from other teachers within the school about what he was doing because many teachers did not see the connection to what they themselves were doing. His remark was a reminder that even when teachers build a network of other teachers outside their school who can support them, it is still important for each school to support its own teachers.

In sum, through our professional-development program, we observed a number of changes in teachers' perspectives toward programming education. One of the major shifts was teachers' understanding of programming education as an opportunity not only to teach how to program but to introduce a new way of learning through trying, making mistakes, reflecting, and iterating. These changes in the way teachers experienced their learning suggest relative success of this professional-development approach. We also see opportunities for development and revision during future iterations.

Recommendations

Based on our investigation of data collected before, during, and after the professional-development program, four lessons about professional development for creative programming have emerged.

First, professional development for creative programming should provide a space for teachers to experience learning activities themselves and gain firsthand experience of engaging in the process of learning. Our interviews indicated that teachers were used to a "sit back and listen" experience during professional development, which is consistent with many other teacher professional-development programs (Hawley & Valli, 2007). Having the experience of doing creative programming on their own enables teachers to truly adapt creative programming approaches to their own educational contexts.

Second, professional development for creative programming should promote a culture of iteration among teachers, encouraging them to be open to new ideas, take risks, and iterate as they go. Many teachers described being in an environment where a mistake was not allowed, which created much resistance to new ideas that might or might not result in good outcomes. It is important to promote a safe environment where teachers can try out and practice a new activity, tool, and idea, not only as part of professional development but also within the school where they teach. In

the case of this study, we collaborated with the prefectural board of education, which also talked to each school where participants were coming from to enable them to try out, test, and iterate in their schools.

Third, professional development for creative programming should be an authentic experience for teachers, meaning that learning and discussion are always grounded in each teacher's classroom environment. Many professional-development programs fail to support teachers to implement the ideas shared during professional development because the learning experiences are decontextualized from the teachers' everyday lives (Borko, 2004). In this study, teachers were given abundant time to reflect on their experiences and write down expectations and concerns when they brought new ideas into their classrooms.

Fourth, professional development for creative programming should enable community development among teachers. The implementation of new ideas takes time and requires organizational adjustments. Many teachers described how they struggled to find support within their school; therefore, they appreciated the chance to ask questions, offer feedback, and share resources with one another during the program using an email Listserv.

Conclusion

This paper has shared insights into how a teacher professional-development program focused on supporting creative learning might positively impact the ways teachers perceive programming education. Analysis of feedback from the participating teachers indicates that our program helped them look at programming education from a different perspective; many participants continued to iterate on the ideas and practices they started developing during the program. Although these insights are limited to one iteration of a professional-development event, they make a promising contribution to the field of professional development of computer programming education given that the many existing professional-development programs focused on a narrow scope of programming education.

The third iteration of this professional-development program is ongoing with a new group of teachers. Several revisions were made based on the analysis of the first iteration in 2018; for example, the opportunity for teachers to practice facilitation of creative learning, such as programming camps and a summer camp on making, were added to the program. However, because of restrictions placed on in-person gatherings after the outbreak of the 2020 pandemic, the third iteration had to be transformed into a fully online format. For future research, closely analyzing participant feedback from the first, second, and third iterations of our professional-development program should provide further insights into successfully implementing professional development for teaching computer programming while supporting creative learning.

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Acknowledgments

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